Shear Stress

Shear stress σ is quantity with units of pressure that is related to the strain rate experienced by a fluid by

$$\sigma \equiv \eta[\text{strain rate}], \tag{1}$$

where η is the dynamic viscosity. Writing out the strain rate then gives

$$\sigma = \eta\dot{\epsilon} = \eta\frac{1}{l}\frac{dl}{dt}. \tag{2}$$

The shear stress thus expressed the tendency of a fluid to be "pulled apart" (sheared) by a differential force, with η acting as a resistance to the shear.

There is a shear stress on a fluid having a velocity u on the upper layer but which is constrained to be zero at a lower boundary at a distance d below the upper surface. For a Newtonian fluid,

$$\frac{du}{dy} = \frac{1}{l}\frac{dl}{dt} = \frac{u}{l}. \tag{3}$$

But the gradient from bottom to top is

$$\frac{du}{dy} = \frac{u}{d}, \tag{4}$$

so

$$l = d \tag{5}$$

and the shear stress is simply given in this case by

$$\sigma = \eta\frac{du}{dy} = \eta\frac{1}{l}\frac{dl}{dt} = \eta\frac{v}{l} = \eta\frac{v}{d}. \tag{6}$$

SEE ALSO: Dynamic Viscosity, Shear, Strain Rate, Stress